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**DESIGNING INNOVATIVE ORGANIZATIONS**  
Design Science Research in the Management Field at TU/e

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# **DESIGNING INNOVATIVE ORGANIZATIONS**

## **Design Science Research in the Management Field at TU/e**

### **Introduction**

Eindhoven University of Technology has a strong focus on design. The Department of Industrial Engineering & Innovation Sciences includes a group (ITEM) conducting design research in the management sciences. This introduction starts with a short introduction of the department. Thereafter, the specific research focus of the Innovation, Technology Entrepreneurship and Marketing (ITEM) Group within the department is briefly introduced.

The Department of Industrial Engineering & Innovation Sciences (IE&IS)(formerly Technology Management) engages in education and research in the area of business processes and transitions in societies in relation to technical changes. In the IE&IS department, scholars and students work together on critical problems at the interface of engineering, management, innovation, and human behavior. The department has two schools: the School of Industrial Engineering and the School of Innovation Sciences. The ITEM group is part of the School of Industrial Engineering

Within the School of Industrial Engineering five degree programs are taught: BSc in Industrial Engineering & Management Science (Technische Bedrijfskunde), BSc in Industrial Engineering for Health Care, MSc in Operations Management & Logistics, MSc in Innovation Management, and PhD in operations, logistics and innovation management. The PhD program is embedded in the research school Beta. The School of Industrial Engineering also participates in the Logistics, Operations & Information Systems (LOIS) research cluster of the TU/e.

The ITEM group within the School of Industrial Engineering performs design research from two perspectives. First of all, research focuses on innovation and design processes, i.e. processes that create new products and new businesses. The group aims to increase understanding of these processes from an organizational point of view and contribute to improving these processes by developing design principles that can be used in practice. Second, methodology is developed for bridging the science-practice gap, focusing on the development of these design principles, thereby increasing relevance of science for practice. Projects and key findings from both perspectives are highlighted in this paper. Furthermore, the presence of the ITEM group in the design community is indicated.

## Studying design processes

The interest in design and designing in the management literature (e.g. Boland and Collopy, 2004) has recently been increasing. Managing is not only seen as decision making, but also as the creation of solutions for problems and the changing of existing situations into desired ones; so, managers are also designers. The students at the Industrial Engineering school are for many years already trained in (re)designing business processes.

Since the focus is on the study of design "processes", often a process approach (Langley, 1999; Poole et al., 2000) is chosen. By adopting such a process research approach, we are able to analyze how issues emerge, develop, grow, or change over time, i.e. how the processes unfold through sequences of events (Van de Ven, 2007). Process research allows the investigation of design processes over an extended time frame.

In the remainder of this section, an overview is given of all recent ITEM projects performed from the perspective of studying design processes in the management field. The projects can mainly be categorized according to three themes: new product development, design of new venture creation and design and development of business models.

### *New product development*

In new product development (NPD), the "traditional" role of designing a product is very evident. An example of a recent project studying design processes in NPD context is the master thesis project of Rutger Stultiens (2009) focusing on *external designers in product design processes of small manufacturing firms*. Small manufacturing firms often fail to reap the benefits of good design practices and make limited use of external designers in their product development processes. The study investigates how the involvement of external designers influences the evolution of product design processes in small manufacturing firms. Qualitative and quantitative process research methods were used to study 352 events in five joint product design projects. The findings show how these processes iterated between divergence and convergence and between goal setting and idea development. Moreover, higher involvement of external designers was associated with more frequent iterations. Designers offered a broad set of skills and activities that were complementary to the small firms. In sum, the study underlines and explains the value of external designers for small manufacturing firms.

The same project also found that product innovation in small firms is not merely unplanned, chaotic, improvisational, or ad hoc, but is guided by underlying "*effectuation*" logic (Sarasvathy, 2001). This effectuation theory originates in the entrepreneurship field. Sarasvathy contrasted effectuation with causation, as two different decision making logics. Causation takes a certain goal or effect as given and focuses on selecting the means to reach

that effect; like cooking based on a recipe. Effectuation takes a set of means as given and focuses on selecting possible effects that can be created by these means; like the opening of the refrigerator and determine what can be prepared with the given ingredients (Sarasvathy 2001, pp. 245; Sarasvathy and Dew, 2005). Effectuation puts low emphasis on prediction, but much on control; causal thinking puts a lot of emphasis on precise prediction and clear goals and planning (Wiltbank et al., 2006). Effectuation is a process of creation that is particularly appropriate under uncertainty, when knowledge of key phenomena does not yet exist.

It is interesting to see that effectuation not only fits the approaches of small firms, but can also be linked to approaches of design processes. The many approaches to organize design processes can roughly be divided into two main categories, namely top down, expert-driven, rational problem solving approaches, versus more bottom-up, participative, reflective practice approaches (cf Dorst, 1997). The first category is often represented in well-known linear and incremental models. The second category more participative processes is modeled as evolutionary or agile approaches (Benediktsson et al., 2006). Effectuation theory fits in the second category of more participative approaches. Sarasvathy (2003) linked effectuation already to designing and mentioned the agile technique SCRUM (Schwaber and Beedle, 2002) as a method using effectuation principles. We are interested in the applicability of the effectuation theory for organizing and supporting (flexibility in) design processes. In the future, more research on effectuation processes will be performed, answering research questions like: Where do effectuation and design thinking differ? Can effectuation be recognized in design processes? Under which conditions is an effectual approach more suited, when is a causal approach suited?

Another study investigated the impact of nine new product development *acceleration approaches on development speed* (Langerak and Hulting, 2008). The findings from 233 manufacturing firms show that 5 approaches (supplier involvement, lead user involvement, speeding up activities and tasks, training and rewarding of employees, and simplification of organizational structure) increase development speed, whereas 2 approaches (implementing support systems and techniques and stimulating inter-functional coordination) decrease development speed. Two approaches (i.e., reduction of parts and components and emphasizing the customer) have no effect on development speed. The results further show that firms developing different types of new products should use different NPD acceleration approaches, as the speed impact of six out of nine approaches is dependent upon the degree of product innovativeness.

A completely different topic is studied in the recently started master thesis project of Laurie Scholten (2010). It concerns customer involvement in design processes and in particular harnessing the *re-invention processes* that take place by these customers after a product has entered the market. The main research questions are "How can a company create

products that can be seen as platforms and triggers for re-invention (by expert and/or novice users)?" and "How can a company effectively use re-invention in the NPD process for creation of the next product line or the improvement of existing products by add-ons or updates?". We are still looking forward to promising results.

Another topic studied in recent years is the *co-evolution of problems and solutions* in architectural meetings in design practice (Reymen, Dorst, and Smulders, 2009). Co-evolution is considered as a key characteristic of designing. Several authors have described design thinking processes as the co-evolution of design problem and design solution. Its theoretical grounding is, however, still in an early stage. In the paper, we aimed to bring further the concept by studying a real life design meeting of an architect and a client. We developed a model of how co-evolution in a multi-party setting might work. We discerned 13 co-evolution episodes in the two studied meetings. We looked in detail at the utterances in two co-evolution episodes. It turns out that modelling co-evolution in terms of problem and solution does not work. Conversation in an area in between problem and solution, like 'use', seems to be more accurate to describe how the actors reach agreement. We proposed alternative ways for modelling co-evolution.

Based on the same raw material, another project was started, focusing on *purposive interventions for creating shared understanding* in design processes (Reymen, Jelinek, and Berends, 2009). Design participants need shared understanding to proceed, and some at least deliberately aim to develop it through interventions in design processes. Process study methodology was used to analyze video recording transcripts of actual architect-client meetings for the design of a crematorium in UK. We concluded that the development of shared understanding can be fostered by deliberate interventions; that nested sub-processes help to explain why and how shared understanding develops in the course of design processes; and that the recurrent patterns that comprise these processes are deliberate and systematic. The study contributes a more detailed model of the development of shared understanding in design efforts.

Finally, we participated in two National Science Foundation workshops on *Design Requirements*, in Cleveland, Ohio and later on also in Dagstuhl, Germany (Reymen and Romme, 2009). Since managing design requirements of complex socio-technical designs in heterogeneous and rapidly-changing environments demands new approaches, we developed a research agenda. We used the framework described by Krippendorff (2006) as a starting point to describe the evolution of requirements thinking. Krippendorff's trajectory of artificiality shows an increasing dematerialization and human-centeredness of artifacts. He distinguishes six kinds of artifacts, namely material products; goods, services, and identities; interfaces; multi-user systems and networks; projects; and finally, discourses. Based on a review of the design literature, involving two major design journals, we found that the design of socio-technical systems currently tends to be situated on the level of multi-user systems

and networks. Projects and discourses hardly get any attention in requirements thinking. We therefore developed an agenda for future research directed toward advancing requirements thinking at the level of projects and discourses as artifacts of design.

### *Design of new venture creation*

Entrepreneurship is an emerging and fast growing field in the organization and management literature. In this discipline, the creation of a new venture is the central phenomenon, which is increasingly considered as a design process, where design knowledge is essential. For example Sarasvathy (2003) views entrepreneurship as a 'design science'. The opposite trend can also be observed: more entrepreneurial thinking in design processes (cf. Dorst, 2008): more attention for thinking in terms of markets and value instead of costs. From our research group, we have contributed to the entrepreneurship literature with a number of design-oriented studies.

A group of studies, around one dissertation (Van Burg, 2010), has focused on the design of entrepreneurship conducive universities. University spin-offs such as Lycos and Genentech are founded to exploit university intellectual property. They serve to transform technological breakthroughs from university research, which would probably remain unexploited otherwise. Therefore, policy makers have become very interested in university spin-offs as a means for technology transfer and economic growth. However, creating university spin-offs is not easy. Some universities generate more spin-offs than others (e.g., Di Gregorio and Shane, 2003; Klofsten and Jones-Evans, 2000; Kondo, 2004). Furthermore, university spin-off activity creates several difficulties, such as the potential conflict of interest between commercial and academic work and the risk to university reputation if founders of spin-offs act inappropriately (Bird, Hayward, and Allen, 1993; Shane, 2004; Slaughter and Rhoades, 2004). On the other hand, academic entrepreneurs feel sometimes that their behavior is not welcomed by the university, or that the university procedures hinder the development of their venture. Thus, the main research question in this stream of research is: How can a university organization be designed that fosters the creation and development of university spin-offs?

This research was motivated by the observation that quite some knowledge has been accumulated about university spin-off creation and entrepreneurship in general, but that it is difficult to connect this wisdom with practices at universities. Therefore, a science-based design approach was adopted to connect the scholarly knowledge base with these practices (Denyer, Tranfield, and Van Aken, 2008; Romme, 2003; Romme and Endenburg, 2006; Van Aken, 2004). This resulted in five design principles, which are grounded in both theory and practice. The results of this study are published in Van Burg et al. (2008). This publication focuses on the university level. Another publication from this research, Gilsing et al. (2010),

focuses on the regional policy level and does also take into account the design of policy to foster the creation and success of corporate spin-offs.

In the endeavor of developing design principles to advise these practitioners and to provide scientists with a framework to assess the state-of-the-art of the scientific knowledge, we identified a number of areas that needed further investigation. Therefore, we performed a study to explore the strategies that designers employ to use knowledge in the design process and to analyze the contribution of these strategies to the performance of the design process. We found that organization designers employ three strategies: off-line reasoning and planning, feedback-driven learning, and associative reasoning by way of analogies (cf. Broadbent, 1973; Tsoukas, 2005). Contextual conditions influence the use of these strategies and affect the associated effectiveness and efficiency of the design process (cf. Farjoun, 2008; Gavetti, Levinthal, and Rivkin, 2008; Simon, 1996). The design strategy of associative reasoning serves to acknowledge differences between the situation at hand and the associated case, which tends to result in design processes with high performance. As such, an analogy can function as a powerful vision to integrate design principles, to avoid lock-in in the current situation and to justify the design solution. In this respect, this study underscores earlier theoretical claims that designers in moderately complex and novel settings preferably engage in associative reasoning by way of analogies (Farjoun, 2008; Gavetti et al., 2008; Gavetti, Levinthal, and Rivkin, 2005; Gavetti and Rivkin, 2007). Moreover, feedback-driven learning is in particular instrumental in adapting given design principles and design solutions to the context. In addition, this design strategy serves to anchor design solutions in the organization and is necessary for the effectiveness of the design process (cf. Perrow, 1972; Weick, 1976). Finally, the execution of the design process, as such, appears to be largely influenced by the experience of agent-designers.

Another group of studies focuses on similar new venturing processes, but now in a corporate context. This research is mainly executed by Sjoerd de Jager (graduate student), Isabelle Reymen, Myriam Cloudt and Elco van Burg. Large, mature organizations are often capable of exploiting existing products efficiently, but are typically less effective in being innovative. Financial systems and bureaucratic procedures adopted to control processes in the mainstream business of large organizations tend to be hostile toward innovative ideas, proposals and initiatives (Dess et al., 2003). One of the solutions to this problem is to structurally separate exploitation tasks and innovative exploration activities (Ambos, Mäkelä, Birkinshaw, and D'Este, 2008; Tushman and O'Reilly, 1996). Although there is quite some dispersed knowledge of the phenomenon, there is a need for guidelines how to properly transfer a corporate venture into the mainstream business realm, and thereby complement the vast amount of knowledge on corporate venturing processes. Here, our studies adopt a design science method to develop design principles grounded in the body of research evidence and meant to increase both the understanding of these kinds of transition



processes as well as to support corporate management in the organization of these activities. Seven design principles were developed, following a similar approach as with the university spin-off design principles. The results of this study are being prepared for publication at this moment. Moreover, we explore some in-depth design issues regarding the corporate venturing process.

### *Design and development of business models*

Several recent projects in our group focus on the design and development of business models. A business model is seen as a set of assumptions of how a company can create and appropriate value for its stakeholders. Many types and frameworks of business models have been developed, but it is still unclear how to "design" a business model, i.e. where to start, on which dimensions to focus, how to deal with the specific context operating in, etc.. Also the development of business models over time is interesting to study; hereby a link can also be made with effectuation theory, e.g. experimenting with several business models in parallel. Graduate student Paul Zuurbier (2008) focused on effectual business concept development and business model innovation, linking business model development with effectuation theory. Business model ideation is currently the topic of graduate student Frank Elbers (2010). He is developing (part of) a creativity method for designing business models. Four other projects (on bachelor, master and Ph.D. level) are started recently on business model design and development topics. Finally, a project was performed in the creative industry focussing on the design of business models for collaboration between heterogeneous partners (like big companies and small firms or independent without personnel (ZZP)); this project will also be continued in a larger research project.

### **Design science methodology**

Members of the ITEM group have worldwide recognition in the management and organization field for their design oriented approach. A number of recent principal and highly cited papers regarding design science methodology have founded this reputation. For example, the paper by Romme (2003) was the first to (re)introduce the design science perspective to organization science. Moreover, Romme and Van Aken have served as the "original pioneers who brought the design sciences to organization studies" (Paul Bate in: Journal of Applied Behavioral Science, vol. 43, 2007, pp. 10). In this respect, googlescholar.com reports more than 100 resp. 200 citations to their publications in Organization Science (Romme, 2003) and Journal of Management Studies (Van Aken, 2004). The approach presented in these papers has developed over several decades in the School of Industrial Engineering. Driving force of the design science research development in management science is the utilization problem or rigor-relevance dilemma. "Management

theory is either scientifically proven, but then too reductionistic and hence too broad or too trivial to be of much practical relevance, or relevant to practice, but then lacking sufficient rigorous justification” (Van Aken, 2004, pp. 221). A number of the seminal papers are discussed below.

Romme (2003) argues that in view of the persistent relevance gap between theory and practice, organization studies should be broadened to include design as one of its primary modes of engaging in research. Design is here typified by its aim to find a solution, guided by broader purposes and ideal target systems. Moreover, design develops, and can draw on, design propositions that are tested in pragmatic experiments and grounded in organization science. This study first explores the main differences and synergies between science and design, and explores how and why the design discipline has largely moved away from academia to other sites in the economy. The argument then turns to the genealogy of design methodologies in organization and management studies. Subsequently, this paper explores the circular design methodology that serves to illustrate the nature of design research. Finally, Romme proposes a framework to guide the interplay between design and science modes.

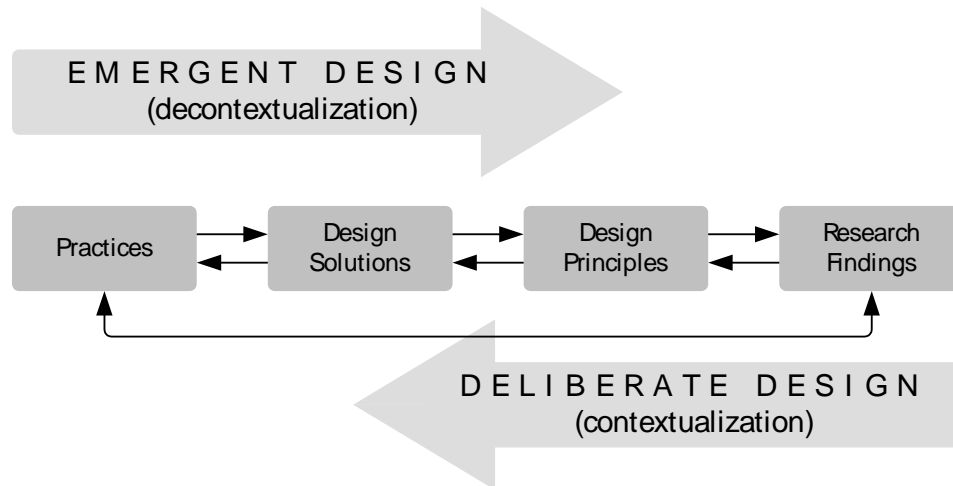
Van Aken (2004) argues similarly that academic management research has a serious utilization problem. In this field mainstream research tends to be description-driven, based on the paradigm of the ‘explanatory sciences’, like physics and sociology, and resulting in what may be called ‘organization theory’. This article argues that the relevance problem can be mitigated if such research were to be complemented with prescription-driven research, based on the paradigm of the ‘design sciences’, like Medicine and Engineering, and resulting in what may be called ‘management theory’. The typical research products in Management Theory would be ‘field-tested and grounded technological rules’. The nature of such rules is discussed as well as the research strategies producing them.

Romme and Endenburg (2006) further detail the design science methodology, and propose science-based organization design that uses construction principles and design rules to guide practitioner-academic projects. Organization science implies construction principles for creating and implementing designs. These principles serve to construct design rules that are instrumental in developing organization designs. Testing and implementing designs require pragmatic experimentation in complex, dynamic settings. The authors explore a circular design process as an example of science-based organization design.

Denyer, Tranfield and Van Aken (2008) refine the methodology to develop science based design principles. These design propositions follow the so-called ‘CIMO-logic’. This logic involves a combination of a problematic Context, for which the design proposition suggests a certain Intervention type, to produce, through specified generative Mechanisms, the intended Outcome(s). They discuss how design-oriented research synthesis provides a vehicle for addressing fragmentation and increasing the chances of application. Moreover,

this study explores how the development of design propositions can result from synthesizing previously published research and illustrate this with the design of high-reliability organizations (HROs).

Van Burg, Romme, Gilsing and Reymen (2008) also develop and illustrate a part of the methodology, especially regarding the actual interplay between practice and research. In the context of entrepreneurship and innovation, design processes tend to be as much emergent as deliberate in nature (Hargadon and Douglas, 2001). The framework in Figure 1 suggests there are ample opportunities for experimentation (practice) to drive the creation of, for example, design solutions and principles. This more emergent design process arises from what Schön (1987) calls reflection-in-action: that is, the rethinking that leads to on the spot experiments as well as the further thinking “that affects what we do – in the situation at hand and perhaps also in others we shall see as similar to it” (Schön, 1987: 29). This emergent quality of the research-design-development cycle in Figure 1 is likely to prevail when design principles are non-existent, underdeveloped, or unknown to practitioners. In a more mature discipline, this cycle is as much emergent as it is deliberate: the emergent dimension serves to respond to and account for the unique and dynamic nature of the local setting, whereas the deliberate dimension serves to build a body of knowledge that cuts across multiple settings. These two faces of design also reflect the need to decontextualize and contextualize design principles and solutions.



*Figure 1: The research-design-development cycle from a science-based design perspective*

Other recent studies from the ITEM group that have a methodological component regarding design science are the following:

(Dunbar, Romme, and Starbuck, 2008; Huff, Tranfield, and Van Aken, 2006; Jelinek, Romme, and Boland, 2008; Romme and Damen, 2007; Van Aken, 2005; Van Aken, 2007; Van Aken and Romme, 2009)

### *Education and broader exposure*

Design science methodology is not just an academic method, but is also used to teach students how to design organizations. For bachelor students, our design approach has been codified in a methodological handbook for business problem solving (Van Aken, Berends, and Van der Bij 2007). For master students, a more in-depth course on ‘Design Science Methodology’ is offered at the School of Industrial Engineering. Moreover, the current redesign of the education program of the School of Industrial Engineering also follows a number of insights from this methodology. Moreover, a group of PhD students gathers every month to discuss the development of design science based dissertations. The name of this group is the ‘Design Science Research Group’, and one of the group’s members has also launched a wiki-page about the approach.<sup>1</sup>

<sup>1</sup> [http://en.wikipedia.org/wiki/Design\\_Science\\_Research](http://en.wikipedia.org/wiki/Design_Science_Research)

## Presence of the ITEM group in the design community

The ITEM group is present in the design community in several ways.

First of all, several people of the ITEM group are member of *professional organizations* affiliated with design, like PDMA (Product Development & Management Association) and DMI (Design Management Institute).

Next, there are *memberships of editorial boards of journals*, focusing on designing. Georges Romme is for the journal Organization Studies responsible for the design related papers. George Romme and Isabelle Reymen are also editorial board members of the new International Journal of Organizational Design and Engineering (IJODE) (since 2009). IJODE is a scholarly journal aiming at the development of organizational design and engineering (ODE), defined as the application of social science, design science and computer science research and practice to the study and implementation of new organizational designs, including the integrated structuring, modeling, development and deployment of IS/IT and social processes. Georges and Isabelle are also member of the program committee of the related International Workshop of Organizational Design and Engineering (IWODE).

Isabelle Reymen was also *associate editor of the design track* of the European Conference on Information Systems in 2008 and 2009 and Joan van Aken of the International conference on Information Systems.

Hans Berends, Georges Romme and Jennifer Whyte *organized a track* on "Exploring the Interface Between Organization Design and the Humanities" at the European Group of Organization Studies (EGOS) Colloquium held in Amsterdam in 2008. Georges Romme co-organized with Sabine Junginger a Personal Development Workshop (PDW) on Design Research at the Academy of Management (AoM) Annual Meeting in 2009, which will be continued at AoM in 2010.

Finally, we *review* for journals like Research in Engineering Design, Organization Studies, Design Studies, Co-Design and several design related conferences.

## Conclusions and further directions

Our group has contributed to developing a design mindset among (management and entrepreneurship) scholars as well as students. We created an improved linkage between science and design practice via the development of design principles. This work on *design science methodology* will be continued in the future via organizing workshops, editing special issues and publishing about the topic. Furthermore, given the increasing importance of entrepreneurship in the design and management field, the linkages between *designing and entrepreneurship* will be reinforced by studying design processes in the context of new

business development. Finally, we will continue working from the more bottom-up, participative, reflective practice like approaches to design processes and their ability to deal with *flexibility in the design process*; the trend for more flexibility is widespread, given the increasing uncertainty and the continuously changing (business) environment.

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